

Digestive System Introduction

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Intended Learning Objectives (ILOs)

:After studying this, you should be able to

Describe the functions of the digestive system -

List the four basic digestive processes: (motility, -
.secretion, digestion and absorption)

Explain the main control mechanisms for digestive -
processes: (autonomous smooth muscle function, intrinsic
nerve plexuses, extrinsic nerves and gastrointestinal
.hormones)

:Digestive system consists of

The digestive (gastrointestinal) tract = gut= -
.alimentary canal

:The accessory digestive organs -

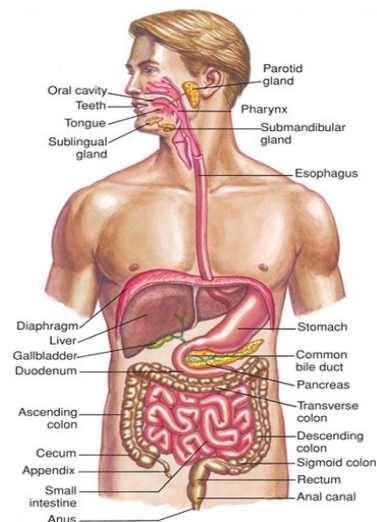
- The salivary glands.
- The exocrine pancreas.
- The liver and gall bladder.

The gastrointestinal tract

:(GIT)

- A tube, 9 meter in length in a cadaver.
- Only half (4.5 meter) that in a living person (because of contractions of the tract's muscular wall).

- Includes: Mouth, Pharynx (throat), Esophagus, Stomach, Small intestine (duodenum, jejunum and ileum), Large intestine (cecum, appendix, colon, rectum and anal canal).



Function of the digestive system is

:performed by four basic digestive processes

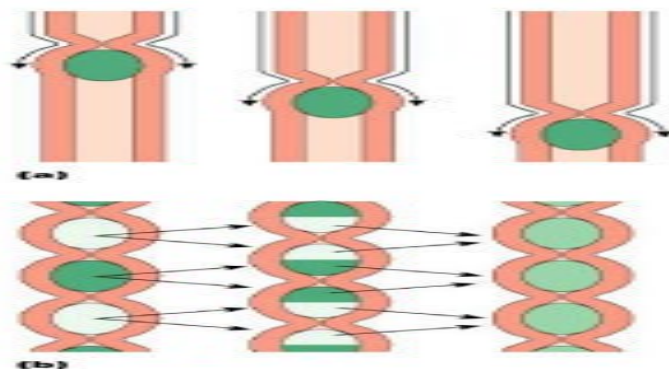
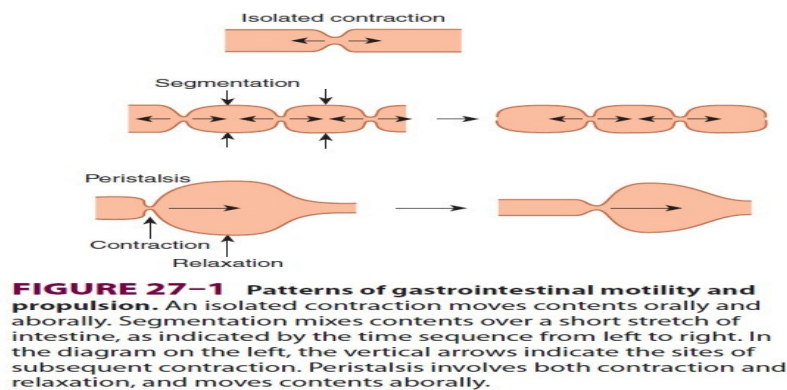
1. Motility.
2. Secretion.
3. Digestion.

4. Absorption.

*Excretion= Elimination of un-digested and un-reabsorbed food in feces by the process of defecation.

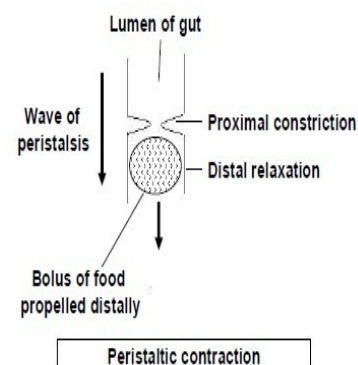
Motility (1)

- ✓ **Definition:** The muscular contractions that mix and move forward the contents of the digestive tract
- ✓ **Types:** There are **2** types;
 - (a) Propulsive movement.
 - (b) Mixing movement.



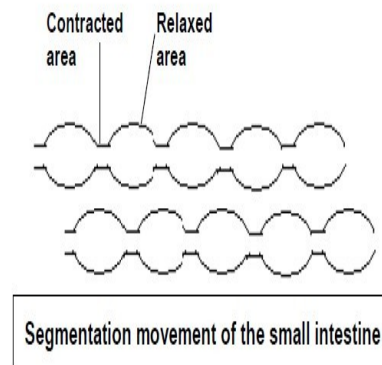
Propulsive movements:

- They **propel** (push) the contents forward through the digestive tract (**peristalsis**).
- Peristalsis is a **reflex** response that is initiated when the gut wall is stretched by the contents of the lumen:
 - The stretch initiates a circular contraction (contractile ring) behind the stimulus and an area of relaxation in front of it.
 - The wave of contraction then moves in an oral to caudal direction, propelling the contents of the lumen forward.



Mixing movements:

- Have 2 functions;
 - **mix** food with digestive enzymes, thus promote digestion.
 - make food come in **contact** with the absorbing surfaces of the digestive tract, thus facilitate absorption.
- Consist of ring like contractions along the length of the small intestine. Within a matter of seconds, the contracted segments relax and the previously relaxed areas contract, thus thoroughly mix the food.



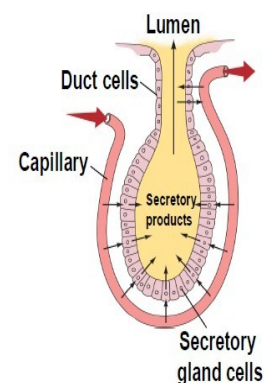
N.B:

- Movement of materials through most of the digestive tract is accomplished by contraction of the **smooth muscles** within the walls, which is under **involuntary control**, except both **oral and anal ends of the tract** (mouth, pharynx, early part of esophagus and external anal sphincter), which contain **skeletal muscles**, are under **voluntary control**.

- Therefore, **the acts of chewing, swallowing and defecation have voluntary components.**

2) Secretion

- A number of digestive juices are secreted into digestive tract lumen by exocrine glands, located along the wall.
- Each digestive secretion consists of:
 - Water
 - Inorganic constituents e.g. electrolytes.
 - Organic constituents e.g. enzymes, bile salts, or mucus.



- ✓ The exocrine gland cells **extract from the plasma** large volumes of H_2O and the raw materials necessary to produce their secretion.
- ✓ Normally, the digestive secretions are **reabsorbed** back into the blood after their participation in digestion.

***** Failure to reabsorb digestive secretions because of vomiting or diarrhea, leads to loss of these fluid and thus decreases plasma volume and blood pressure.**

3) Digestion

Definition: Breakdown of large food molecules (carbohydrates, proteins and fats) into simple absorbable units (glucose, amino acids & fatty acids) by mechanical and chemical (the enzymes produced within the digestive system) means.

Types of digestion:

- 1) Mechanical digestion (by motility)
- 2) Chemical digestion (by secretions)

4) Absorption

- Most absorption occurs in the **small intestine**.
- Small absorbable units that result from digestion, in addition to H₂O and electrolytes (in digestive tract lumen), are absorbed into blood and lymph.

Regulation of digestive function by 4 factors:

- .Autonomous smooth muscle function (1)
- .Intrinsic nerve plexuses (enteric nervous system) (2)
- .Extrinsic nerves (autonomic nervous system) (3)
- .Gastrointestinal hormones (4)

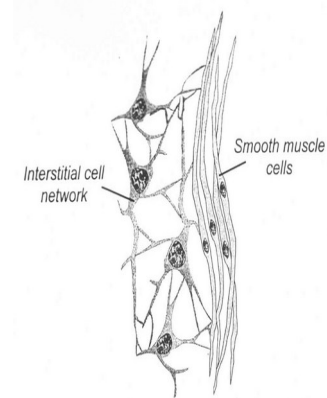
1) Autonomous smooth muscle function:

Like self excitable cardiac muscle cells, some smooth muscle - cells are pace maker (pace-setter) cells, :they

Are Located between the longitudinal - .and circular muscle layers

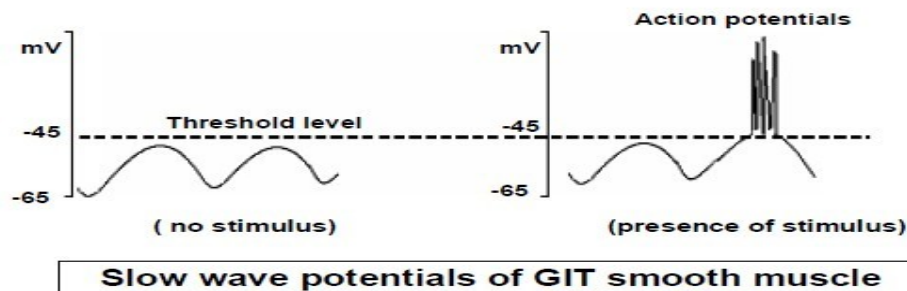
Are noncontractile cells called interstitial - cells of Cajal

Do not have a constant resting - membrane potential, but initiate (induce) .slow wave potentials

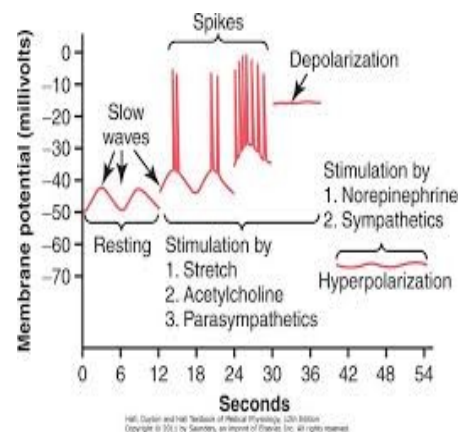


The slow-wave potentials (also, called basic electrical rhythm) (BER):

- ✓ Are not action potentials.
- ✓ Do not directly induce muscle contraction because they do not cause Ca^{2+} to enter the smooth muscle fiber.
- ✓ Are spontaneous, rhythmic, wave-like changes in the membrane potential (so called slow-wave potentials).
- ✓ Might result from slow undulation of the pumping activity of the



- Na⁺-K⁺ pump.
- ✓ Cyclically, bring the membrane potential closer to or farther from threshold potential.
- ✓ If the wave's peak reaches threshold, a number of action potentials is triggered at each peak, resulting in rhythmic cycles of muscle contraction.



Factors influencing the slow-wave potentials:

They are affected by mechanical (e.g., stretch of the wall),
nervous and hormonal factors

:Presence of food in the digestive tract *

- .stimulates mechanical, nervous and hormonal pathways
- peak of the slow-wave potential reaches threshold
- action potentials at the peak followed by muscle contraction

Electromechanical activity:

Rate of muscle contraction:

Depends on the inherent rate of slow-wave potential in each organ

in stomach: 3 waves / min-

in duodenum: 12 waves / min-

in ileum: 9 waves / min-

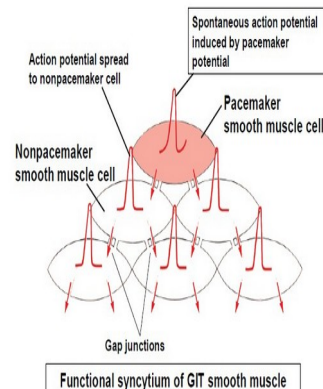
in cecum: 2 waves/min-

in sigmoid colon: 6 waves/min-

Intensity of muscle contraction:

Depends on the number of action potentials triggered at each peak, because increase number of action potentials causes

Increase in cytosolic Ca^{2+} concentration → increase in cross-bridge activity → stronger contraction



Functional syncytium of the GIT smooth muscle:

Sheets of smooth muscle cells are connected by gap junction, which serve as points of low electrical resistance (permit movement of ions between adjacent cells)

If threshold is reached and action potentials are triggered in pacemaker (pace-setter) cells

Through gap junctions, action potentials spread rapidly to all smooth muscle cells

→ So, the whole smooth muscle sheet contracts as a unit (functional syncytium)

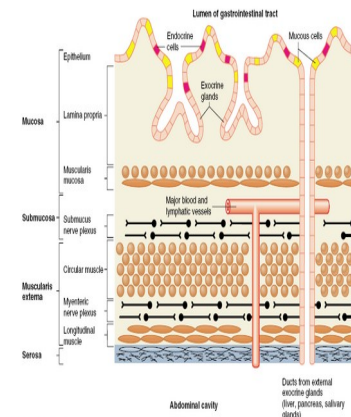
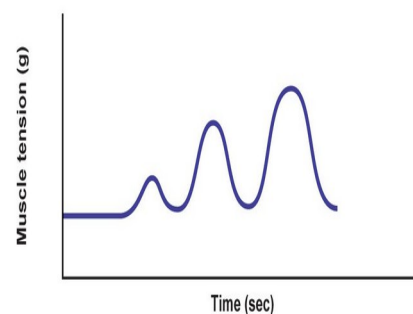
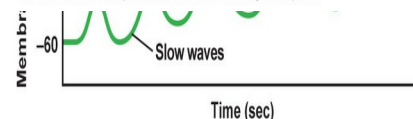


FIGURE 17-6 Structure of the gastrointestinal wall in longitudinal section. Not shown are the smaller blood vessels and lymphatics, neural connections between the two nerve plexuses, and neural terminations on muscles, glands and epithelium.



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2) Intrinsic nerve plexuses (enteric nervous system= gut brain):

Are interconnecting network of nerve cells (neurons)

;Consist of: 2 plexuses -

a) Myenteric (Auerbach's) plexus:

located between the longitudinal and circular smooth muscle layers and concerned with control of GIT motility

b) Submucous (Meissner's) plexus:

located in the submucosa and concerned with control of GIT secretion

- Both plexuses innervate and act directly on:
 - .Smooth muscle cells: regulate digestive tract motility ·
 - .Exocrine gland cells: regulate digestive secretion ·
 - .Endocrine gland cells: regulate GI hormones ·
 - .Coordinate local activity within the digestive tract -
 - .Their activity is influenced by extrinsic nerves -

3) Extrinsic nerves:

They are the autonomic nerves (sympathetic and - parasympathetic) that innervate the various digestive organs

They influence digestive tract motility and secretion by - :3 ways

- .Direct effect on the smooth muscle and glands ·
- .Altering the activity of the intrinsic nerve plexuses ·
- .Altering the level of GI hormone secretion ·

Gastrointestinal reflexes:

The wall of the digestive tract contains 3 types of sensory receptors that respond to local chemical or mechanical changes :in the digestive tract

Chemoreceptors: sensitive to chemical substances (e.g. (1 .food) within the lumen

Mechanoreceptors (pressure receptors): sensitive to stretch (2 .or tension within the wall

Osmoreceptors: Sensitive to the osmolarity of the luminal (3 .contents (Hypotonic and hypertonic fluid)

***Short reflexes:**

They are local reflexes that occur entirely within GIT wall, via - intrinsic plexuses
from GIT receptors to intrinsic nerve plexuses and back to GIT)
.(wall

They regulate motility and secretion in a local area of the -
digestive tract
:Long reflexes*

They extend from GIT wall to spinal cord, or to brain stem and -
.then back to GIT wall, via autonomic nerves

They coordinate motility and secretion of different regions of -
digestive system

:Long reflexes*

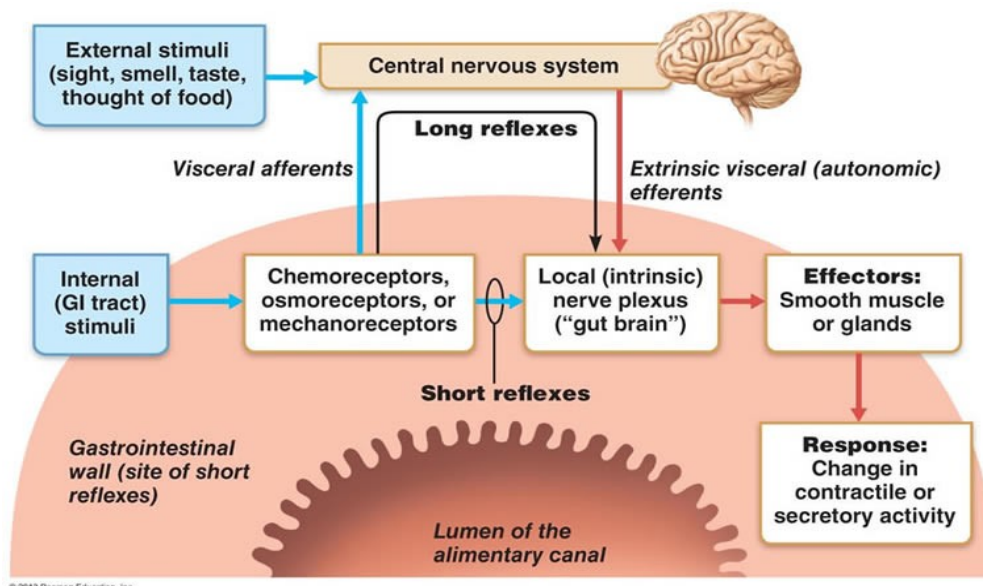
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They coordinate motility and secretion of different regions of -
.digestive system

Gastrointestinal reflexes (Short & Long)

4) Gastrointestinal hormones:

- ❖ Released by endocrine gland cells in the mucosa of digestive tract, and then carried through blood to other areas of the digestive tract, where they exert either excitatory or inhibitory effects on GI motility and secretion.
- ❖ Released primarily in response to specific local changes in the intraluminal contents (e.g., protein, fat, or acid), acting either directly on endocrine gland cells or indirectly through the local enteric nervous system (intrinsic plexuses) or autonomic nerves.



Physiological functions of the different parts of the digestive system:

:The physiological functions of the mouth

.Taste sensation (containing taste buds) .1
Reflexes initiated from receptors located in the mouth .2
(stimulated by presence of food) to stimulate gastric, intestinal
and pancreatic secretion in anticipation to arrival of food
Chewing (mastication): Mechanical processing of food .3
Salivary secretion .4
Digestion: Chemical processing of food (Salivary amylase, .5
lipase)& Mechanical processing (mastication)
.Absorption of some substances (e.g. sublingual nitroglycerin) .6

:The physiological functions of the esophagus

Swallowing or deglutition, which is the process of moving food .1
from the mouth through the esophagus into the stomach
Secretions: mucus (Protection, Lubrication) .2
No digestion .3
No absorption .4

The physiological functions of the stomach:

:Motor .1

- Storage
- Mixing
- Emptying

:Secretory .2

- Exocrine (HCL, mucus, intrinsic factor, pepsinogen)
- Endocrine (Gastrin)

Digestive (proteins and lipids) .3
Absorption: water, alcohol and aspirin .4

:Physiological functions of Small intestine

Motility: Both peristaltic and segmentation movement .1
Secretion: Succus entericus (Intestinal juice) .2
Digestion: Enzymes are intracellular (Disaccharidases and .3
.aminopeptidases)
Absorption: major site of absorption due to its large surface area .4
(Villi, Microvilli). (Site where most digestion and absorption take
.place)

:Physiological functions of Large intestine

Storage of feces (undigested food) then excretion by .1
.defecation
.Secretion of mucus for lubrication .2
.No digestive function .3
.Absorption of water, Na⁺ and other minerals .4

Bacteria in colon synthesize vitamin K and a number of B .5
.complex vitamins